The documentation and process conversion measures necessary to comply with this document shall be completed by 22 May 2010.

INCH-POUND

MIL-PRF-19500/527E
22 February 2010
SUPERSEDING
MIL-PRF-19500/527D
w/AMENDMENT 1
8 March 2007

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, DARLINGTON TRANSISTOR, PNP, SILICON, POWER,
TYPES 2N6648, 2N6649, AND 2N6650, JAN, JANTX, AND JANTXV

This specification is approved for use by all Departments and Agencies of the Department of Defense.

The requirements for acquiring the product described herein shall consist of this specification sheet and MIL-PRF-19500.

1. SCOPE

1.1 Scope. This specification covers the performance requirements for PNP silicon, darlington power transistor. Three levels of product assurance are provided as specified in MIL-PRF-19500.

1.2 Physical dimensions. See figure 1 (TO-3).

1.3 Maximum ratings unless otherwise specified T_A = +25°C.

Types	P_T (1) T_A = +25°C	P_T (2) T_C = +25°C	V_{CBO}	V_{CEO}	V_{EBO}	I_B	I_C	T_J and T_{STG}	$R_{\theta JC}$
	W	W	V dc	V dc	V dc	A dc	A dc	°C	°C/W
2N6648	5.0	85	-40	-40	-5.0	-0.25	-10	-65 to +175	1.76
2N6649	5.0	85	-60	-60	-5.0	-0.25	-10	-65 to +175	1.76
2N6650	5.0	85	-80	-80	-5.0	-0.25	-10	-65 to +175	1.76

(1) Derate linearly 33.3 mW/°C above T_A > +25°C.
(2) Derate linearly 567 mW/°C above T_C > +25°C.

* Comments, suggestions, or questions on this document should be addressed to Defense Supply Center, Columbus, ATTN: DSCC-VAC, P.O. Box 3990, Columbus, OH 43218-3990, or emailed to Semiconductor@dscc.dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.daps.dla.mil .

1.4 Primary electrical characteristics.

	h_{FE1} (1)	h_{FE2} (1)	$V_{CE(SAT)1}$ (1)	$V_{CE(SAT)2}$ (1)	$V_{BE(ON)1}$ (1)
	V_{CE} = -3 V dc I_C = -1 A dc	V_{CE} = -3 V dc I_C = -5 A dc	I_C = -5.0 A dc I_B = -10 mA dc	I_C = -10 A dc I_B = -0.1 A dc	V_{CE} = -3.0 V dc I_C = -5.0 A dc
			V dc	V dc	V dc
Minimum	300	1,000			
Maximum		20,000	-2.0	-3.0	-2.8

	C_{obo}	$\|h_{fe}\|$	Pulse response	
	V_{CB} = 10 V dc I_E = 0 100 kHz ≤ f ≤1 MHz	V_{CE} = -5.0 V dc I_C = -1.0 A dc f = 1 MHz	t_{on}	t_{off}
	pF		µs	µs
Minimum		30		
Maximum	300	400	2.5	10.0

(1) Pulsed (see 4.5.1).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-19500 - Semiconductor Devices, General Specification for.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-750 - Test Methods for Semiconductor Devices.

* (Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch or https://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

* 2.3 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

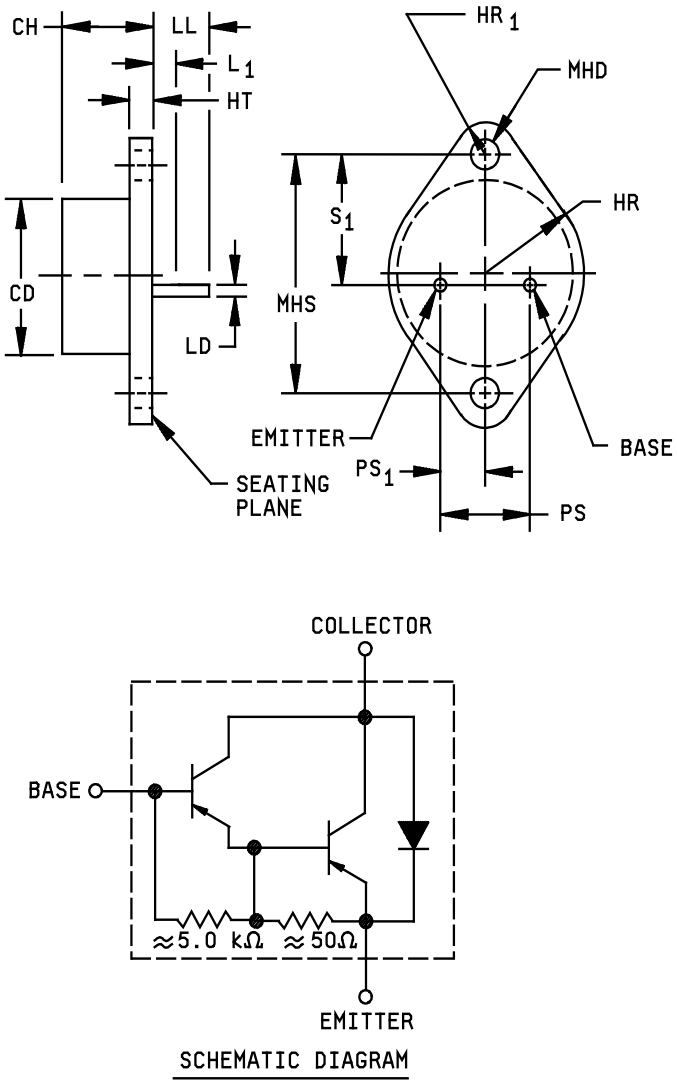


FIGURE 1. Dimensions and configuration (TO-3).

Symbol	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD		.875		22.23	
CH	.250	.450	6.35	11.43	
HR	.495	.525	12.57	13.34	
HR_1	.131	.188	3.33	4.78	
HT	.050	.135	1.27	3.43	
LD	.038	.043	0.97	1.09	
LL	.312	.500	7.92	12.70	
L_1		.050		1.27	
MHD	.151	.161	3.84	4.09	
MHS	1.177	1.197	29.90	30.40	
PS	.420	.440	10.67	11.18	3
PS_1	.205	.225	5.21	5.72	3
s_1	.655	.675	16.64	17.15	

NOTES:
1. Dimensions are in inches.
2. Millimeters are given for general information only.
3. These dimensions should be measured at points .050 inch (1.27 mm) and .055 inch (1.40 mm) below seating plane. When gauge is not used measurement will be made at the seating plane.
4. The seating plane of the header shall be flat within .001 inch (0.03 mm) concave to .004 inch (0.10 mm) convex inside a .930 inch (23.62 mm) diameter circle on the center of the header and flat within .001 inch (0.03 mm) concave to .006 inch (0.15 mm) convex overall.
5. Mounting holes shall be deburred on the seating plane side.
6. Collector is electrically connected to the case.
7. In accordance with AMSE Y14.5M, diameters are equivalent to ϕx symbology.

FIGURE 1. Dimensions and configuration (TO-3) - Continued.

3. REQUIREMENTS

3.1 General. The individual item requirements shall be as specified in MIL-PRF-19500 and as modified herein.

3.2 Qualification. Devices furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.2 and 6.3).

3.3 Abbreviations, symbols, and definitions. Abbreviations, symbols, and definitions used herein shall be as specified in MIL-PRF-19500 and as follows.

$R_{\theta JC}$ Thermal resistance junction to case.

3.4 Interface and physical dimensions. Interface and physical dimensions shall be as specified in MIL-PRF-19500, and on figure 1.

3.4.1 Lead finish. Lead finish shall be solderable in accordance with MIL-PRF-19500, MIL-STD-750, and herein. Where a choice of lead finish is desired, it shall be specified in the acquisition document (see 6.2).

3.5 Electrical performance characteristics. Unless otherwise specified herein, the electrical performance characteristics are as specified in 1.3, 1.4, and table I.

3.6 Electrical test requirements. The electrical test requirements shall be as specified in table I.

3.7 Marking. Marking shall be in accordance with MIL-PRF-19500.

3.8 Workmanship. Semiconductor devices shall be processed in such a manner as to be uniform in quality and shall be free from other defects that will affect life, serviceability, or appearance.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.2).

b. Screening (see 4.3).

c. Conformance inspection (see 4.4).

4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-PRF-19500 and as specified herein.

4.2.1 Group E qualification. Group E inspection shall be performed for qualification or re-qualification only. In case qualification was awarded to a prior revision of the specification sheet that did not request the performance of table II tests, the tests specified in table II herein that were not performed in the prior revision shall be performed on the first inspection lot of this revision to maintain qualification.

* 4.3 Screening (list applicable JAN levels). Screening shall be in accordance with table E-IV of MIL-PRF-19500 and as specified herein. The following measurements shall be made in accordance with table I herein. Devices that exceed the limits of table I herein shall not be acceptable.

Screen (table E-IV) of MIL-PRF-19500.	Measurement
	JANTX and JANTXV levels
(1) 3c	Thermal impedance (see 4.3.2)
7	Optional
11	I_{CEX1} and h_{FE1}
12	See 4.3.1
13	Subgroup 2 of table I herein; ΔI_{CEX1} = 100 percent of initial value or 2 μA dc, whichever is greater. Δh_{FE1} = ± 25 percent of initial value.
14	Required

(1) May be performed anytime before screen 9.

4.3.1 Burn-in conditions. T_J = 162.5 ± 12.5°C, 2N6648 = V_{CB} = -30 V dc, 2N6649 = V_{CB} = -40 V dc, 2N6650 = V_{CB} = -60 V dc.

4.3.2 Thermal impedance. The thermal impedance measurements shall be performed in accordance with method 3131 of MIL-STD-750 using the guidelines in that method for determining I_M, I_H, t_H, t_{SW} (V_C and V_H where appropriate). Measurement delay time (t_{MD}) = 70 μs max. See table II, group E, subgroup 4 herein.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500, and as specified herein.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with table E-V of MIL-PRF-19500, and table I herein. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-VIb of MIL-PRF-19500 and herein Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

* 4.4.2.1 Group B inspection, appendix E, table E-VIb (JAN, JANTX and JANTXV) of MIL-PRF-19500

Subgroup	Method	Conditions
B3	1037	For solder die attach: $V_{CB} \geq 10$ V dc, 2,000 cycles, $T_A \leq 35°C$.
B3	1026	For eutectic die attach: $V_{CB} \geq 10$ V dc, $T_A \leq 35°C$ adjust P_T to achieve $T_J = 150°C$ minimum.
B6	1032	$T_{STG} = +175°C$

* 4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-VII of MIL-PRF-19500. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

* 4.4.3.1 Group C inspection, appendix E, table E-VII of MIL-PRF-19500.

Subgroup	Method	Conditions
C2	2036	Test condition A, weight = 10 pounds, t = 15 s.
* C5	3131	$R_{\theta JC} = 1.76°C/W$. See 4.3.2 herein.
C6	1037	For solder die attach: $V_{CB} \geq 10$ V dc, 6,000 cycles, $T_A \leq 35°C$.
C6	1026	For eutectic die attach: $V_{CB} \geq 10$ V dc, $T_A \leq 35°C$ adjust P_T to achieve $T_J = 150°C$ minimum.

4.4.4 Group E inspection. Group E inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-IX of MIL-PRF-19500 and as specified in table II herein. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2.

4.5 Method of inspection. Methods of inspection shall be as specified in the appropriate tables and as follows.

4.5.1 Pulse measurements. Conditions for pulse measurement shall be as specified in section 4 of MIL-STD-750.

* TABLE I. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Visual and mechanical examination	2071	n = 45 devices, c = 0				
Subgroup 2						
Thermal impedance 2/	3131	See 4.3.2	$Z_{\theta JX}$			°C/W
Collector – emitter breakdown voltage	3011	Bias condition D; I_C = 200 mA dc pulsed (see 4.5.1).	$V_{(BR)CEO}$			V dc
2N6648				-40		
2N6649				-60		
2N6650				-80		
Collector - emitter breakdown voltage	3011	Bias condition B; I_C = 200 mA dc R_{BB} = 100 ohms, pulsed (see 4.5.1).	$V_{(BR)CER}$			V dc
2N6648				-40		
2N6649				-60		
2N6650				-80		
Collector - emitter cutoff current	3041	Bias condition D	I_{CEO}		-1	mA dc
2N6648		V_{CE} = -40 V dc				
2N6649		V_{CE} = -60 V dc				
2N6650		V_{CE} = -80 V dc				
Emitter - base cutoff current	3061	Bias condition D; V_{EB} = 5 V dc	I_{EBO}		-10	mA dc
Collector - emitter cutoff current	3041	Bias condition D; V_{BE} = 1.5 V dc	I_{CEX1}		10	µA dc
2N6648		V_{CE} = -40 V dc				
2N6649		V_{CE} = -60 V dc				
2N6650		V_{CE} = -80 V dc				
Collector - base cutoff current	3036	Bias condition D	I_{CBO}		-1	mA dc
2N6648		V_{CE} = -40 V dc				
2N6649		V_{CE} = -60 V dc				
2N6650		V_{CE} = -80 V dc				

See footnotesat end of table.

* TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 2 - Continued						
Base - emitter voltage (non- saturated)	3066	Test condition B; V_{CE} = -3.0 V dc, I_C = -5.0 A dc; pulsed (see 4.5.1)	$V_{BE(on)1}$		-2.8	V dc
Base - emitter voltage (non- saturated)	3066	Test condition B; V_{CE} = -3.0 V dc, I_C = -10 A dc; pulsed (see 4.5.1)	$V_{BE(on)2}$		-4.5	V dc
Collector - emitter saturated voltage	3071	I_C = -5.0 A dc; I_B = -10 mA dc	$V_{CE(sat)1}$		-2.0	V dc
Collector - emitter saturated voltage	3071	I_C = -10 A dc; I_B = -0.1 A dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$		-3.0	V dc
Forward - current transfer ratio	3076	V_{CE} = -3.0 V dc; I_C = -1.0 A dc pulsed (see 4.5.1)	h_{FE1}	300		
Forward - current transfer ratio	3076	V_{CE} = -3.0 V dc; I_C = -5 A dc pulsed (see 4.5.1)	h_{FE2}	1,000	20,000	
Forward - current transfer ratio	3076	V_{CE} = -3.0 V dc; I_C = -10 A dc pulsed (see 4.5.1)	h_{FE3}	100		
Subgroup 3						
High - temperature operation:		T_A = +150°C				
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = 1.5 V dc	I_{CEX2}		-3.0	mA dc
2N6648		V_{CE} = -40 V dc				
2N6649		V_{CE} = -60 V dc				
2N6650		V_{CE} = -80 V dc				
Low - temperature operation:		T_A = -65°C				
Forward - current transfer ratio	3076	V_{CE} = -3.0 V dc I_C = -5.0 A dc pulsed (see 4.5.1)	h_{FE4}	200		

See footnotesat end of table.

* TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 4						
Pulse response:	3251	Test condition A, except test circuit and pulse requirements in accordance with figure 2.				
Turn-on time		V_{CE} = -30 V dc; I_C = -5.0 A dc; I_{B1} = -20 mA dc	t_{on}		2.5	µs
Turn-off time		V_{CE} = -30 V dc; I_C = -5.0 A dc; I_{B1} = - I_{B2} = 20 mA dc	t_{off}		10.0	µs
Magnitude of small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = -5.0 V dc I_C = -1.0 A dc, f = 1.0 MHz	$\|h_{fe}\|$	30	400	
Open circuit output capacitance	3236	V_{CB} = 10 V dc, I_E = 0, 100 kHZ ≤ f ≤ 1 MHz	C_{obo}		300	pF
Subgroup 5						
Safe operating area (continuous dc)	3051	T_C = 25°C; t = 1 s; 1 cycle; (see figure 3)				
Test 1		V_{CE} = 8.5 V dc; I_C = -10 A dc				
Test 2		V_{CE} = 25 V dc; I_C = -3.4 A dc				
Test 3 2N6648 2N6649 2N6650		V_{CE} = -40 V dc; I_C = -0.9 A dc V_{CE} = -60 V dc; I_C = -0.3 A dc V_{CE} = -80 V dc; I_C = -0.14 A dc				
Electrical measurements		See table I, subgroup 2				
Safe operating area (switching)	3053	Load condition C (unclamped inductive load) (see figure 4); T_C = +25°C; duty cycle ≤ 10 percent; R_S ≤ 0.1 ohms.				
Test 1		t_p = 1 ms; (vary to obtain I_C); R_{BB1} = 1 k ohms; V_{BB1} = -10 V dc; R_{BB2} = ∞; V_{BB2} = 0; I_C = -10 A dc; V_{CC} = -30 V dc; R_L = 0.5 ohms; L = 0.25 mH at 10 A dc				
Test 2		t_p = 1 ms; (vary to obtain I_C); R_{BB1} = 10 k ohms; V_{BB1} = -10 V dc; R_{BB2} = ∞; V_{BB2} = 0; I_C = -0.2 A dc; V_{CC} = -30 V dc; R_L = 0.5 ohms; L = 20 mH at 0.2 A dc				

See footnotesat end of table.

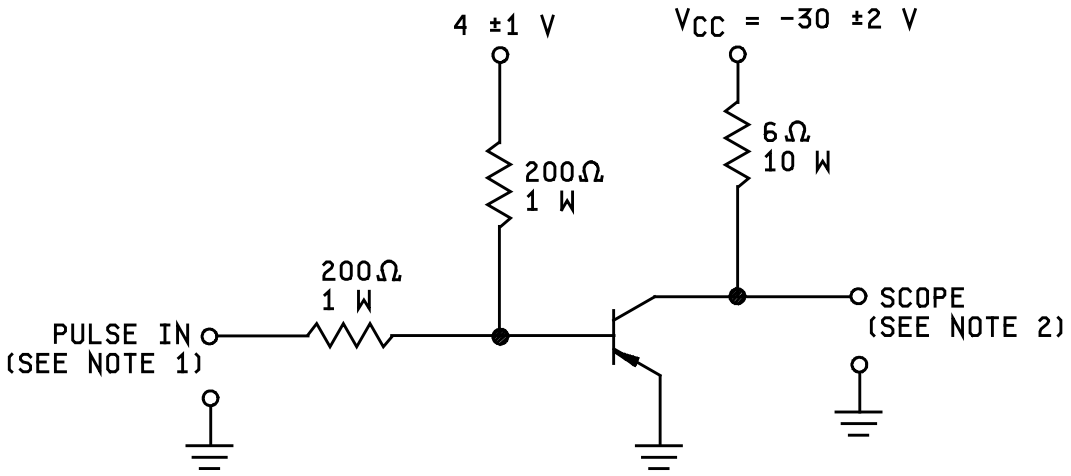
* TABLE I. Group A inspection - Continued.

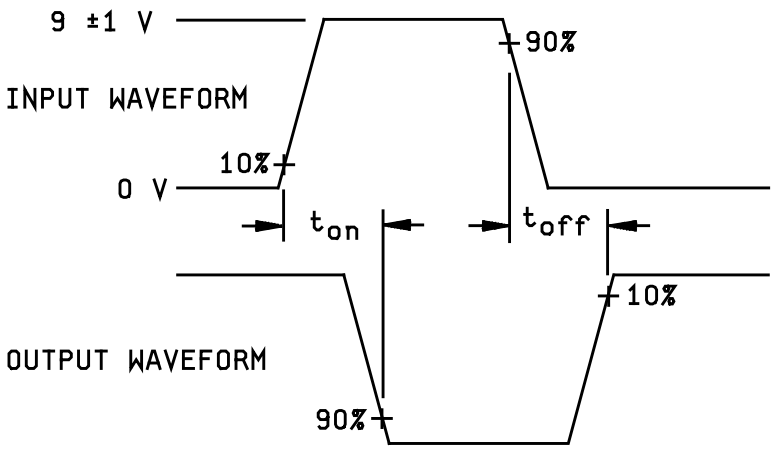
Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 5 - Continued						
Safe operating area (switching)		Load condition B (clamped inductive load) (see figure 5); T_A = +25°C; $t_r + t_f \leq 1.0$ µs; duty cycle ≤ 10 percent; t_p = 5 ms; (vary to obtain I_C); R_s = 0.1 ohms; V_{CC} = -10 V dc; I_C = -10 A dc				
2N6648 2N6649 2N6650		Clamp voltage = -40 V dc Clamp voltage = -60 V dc Clamp voltage = -80 V dc Device fails if clamp voltage not reached.				
Electrical measurements		See table I, subgroup 2				
Subgroups 6 and 7						
Not applicable						

1/ For sampling plan see MIL-PRF-19500.
* 2/ This test required for the following end-point measurements only:
Group B, subgroups 2 and 3.
Group C, subgroups 2 and 6.
Group E, subgroup 1.

* TABLE II. Group E inspection (all quality levels) - for qualification or re-qualification only.

Inspection	MIL-STD-750		Qualification
	Method	Conditions	
Subgroup 1			45 devices c = 0
Temperature cycling	1051	Test condition C, 500 cycles	
Hermetic seal	1071		
Fine leak Gross leak			
Electrical measurements		See table I, subgroup 2 herein.	
Subgroup 2			45 devices c = 0
DC blocking life	1048	T_A = +150°C, V_{CB} = 80 percent of rated voltage, 1,000 hours.	
Electrical measurements		See table I, subgroup 2 herein.	
Subgroup 4			
Thermal impedance curves		See MIL-PRF-19500.	Sample size N/A
Subgroup 5			
Not applicable			
Subgroup 6			3 devices
Electrostatic discharge (ESD)	1020		
Subgroup 8			45 devices c = 0
Reverse stability	1033	Condition B.	





NOTES:

1. The rise time (t_r) and fall time (t_f) of the applied pulse shall be each < 20 ns; duty cycle < 2 percent; generator source impedance shall be 50Ω; pulse width = 20 ns.
2. Output sampling oscilloscope: Z_{IN} > 100 kΩ; C_{IN} < 50 pF; rise time < 20 ns.

FIGURE 2. Pulse response test circuit.

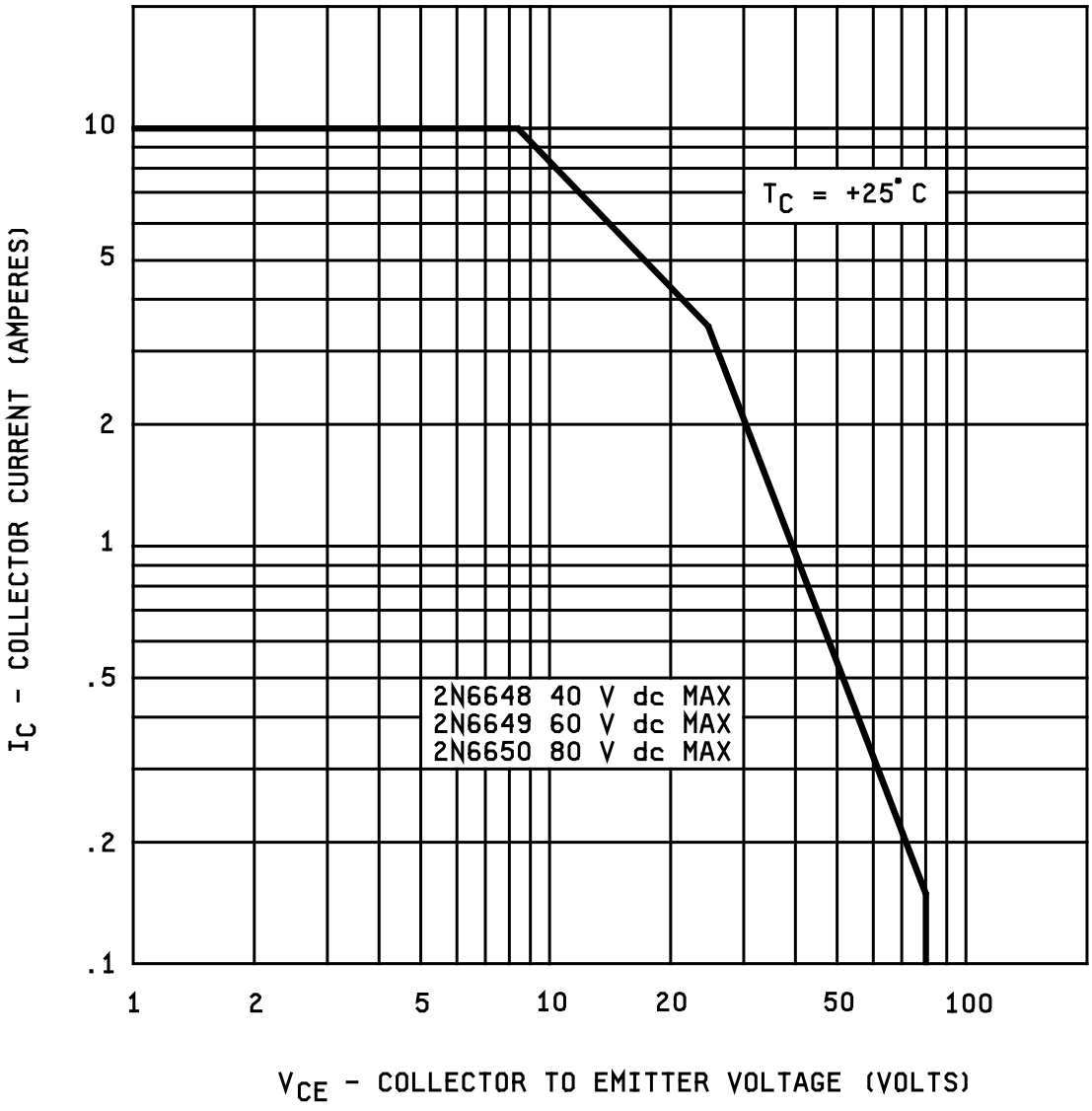


FIGURE 3. Maximum safe operating area graph (continuous dc).

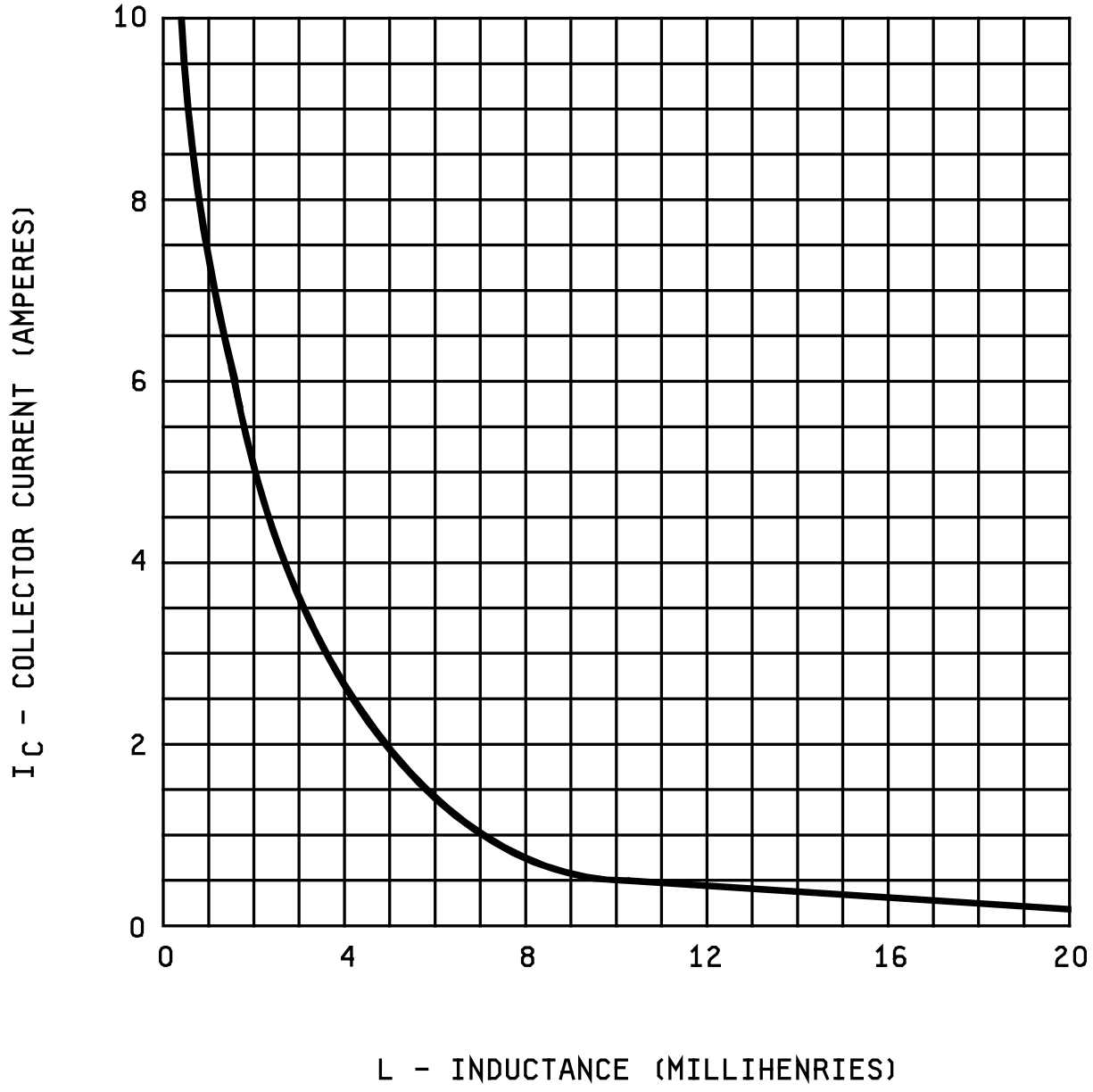
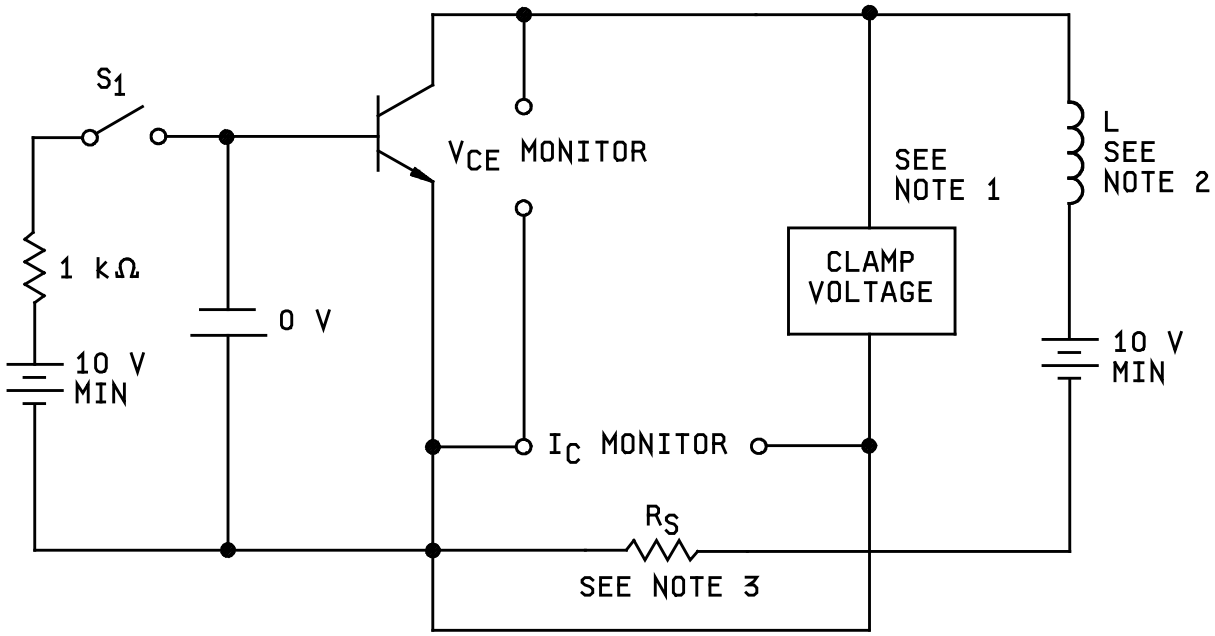


FIGURE 4. Safe operating area for switching between saturation and cutoff (unclamped inductive load).



Procedures:

1. With switch S1 closed, set the specified test conditions.
2. Open S1. Device fails if clamp voltage not reached and maintained until the current returns to zero.
3. Perform specified end-point tests.

NOTES:

1. Either a clamping circuit or clamping diode may be used.
2. The coil used shall provide a minimum inductance of 0.25 mH at 10 A with a maximum dc resistance of 0.1Ω.
3. $R_S \leq 0.1\Omega$. 12 W, 1 percent tolerance maximum (noninductive).

FIGURE 5. Clamped inductive sweep test circuit.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the Military Service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory. The notes specified in MIL-PRF-19500 are applicable to this specification.)

6.1 Intended use. Semiconductors conforming to this specification are intended for original equipment design applications and logistic support of existing equipment.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Packaging requirements (see 5.1).

c. Lead finish (see 3.4.1).

d. Product assurance level and type designator.

* 6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Manufacturers List (QML 19500) whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Defense Supply Center, Columbus, ATTN: DSCC/VQE, P.O. Box 3990, Columbus, OH 43218-3990 or e-mail vqe.chief@dla.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://assist.daps.dla.mil .

* 6.4 Changes from previous issue. The margins of this specification are marked with asterisks to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

Custodians:
Army - CR
Navy - EC
Air Force - 85
NASA - NA
DLA - CC

Review activities:
Navy - MC
Air Force - 19

Preparing activity:
DLA - CC

(Project 5961-2009-019)

* NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.daps.dla.mil.